

Concussion Management

Goals and Objectives

Course Description

“Concussion Management” is a live (real-time) interactive webinar for rehabilitation professionals that examines the clinical management of post-concussion syndrome. This course includes a review of current literature relating to pathophysiology, clinical presentation, and rehabilitation considerations for evaluation and treatment of post-concussion syndrome.

Course Rationale

The purpose of this course is to provide participants with contemporary information on concussion management with comparative analysis of pathogenesis and clinical presentation to understand rehabilitation considerations and maximize outcomes based on current research.

Course Goals and Objectives

Upon completion of this course, participants will be able to:

1. Define the diagnoses of concussion and post-concussion syndrome.
2. List and identify key risk factors predictive of post-concussion syndrome.
3. Recognize the pathophysiology of mild traumatic brain injury classified as concussion.
4. Identify the common symptom presentation patterns of post-concussion syndrome.
5. Recognize the clinical assessment tools needed to evaluate the autonomic, cervical, vestibular ocular, and motor function systems in post-concussion syndrome.
6. Identify the indications for evaluation of cognition and emotional affect in post-concussion syndrome.
7. Identify key features of an effective post-concussion treatment program including the role of rest, timing of treatment, and education.
8. Distinguish impairment-based rehabilitation interventions for patients with post-concussion syndrome.
9. List the common indications for medical clearance and return to sport after concussion.
10. Recognize the prognosis for patients recovering from post-concussion syndrome.

Course Provider – Innovative Educational Services

Course Instructor – Sara Ziegele, PT, DPT, OCS

Target Audience – Physical Therapists, Physical Therapist Assistants

Course Educational Level – This course is applicable for introductory/intermediate learners.

Course Prerequisites – None

Method of Instruction/Availability – Live Interactive Webinar available on scheduled dates/times.

Criteria for Issuance of CE Credits – Attendance at live interactive webinar and a score of 70% or greater on the course post-test.

Continuing Education Credits – Three (3) hours of continuing education credit.

Course Fee - \$39.95

Conflict of Interest – No conflict of interest exists for the presenter or provider of this course.

Refund Policy - Unrestricted 100% refund upon request. The request for a refund by the learner shall be honored in full without penalty or other consideration of any kind. The request for a refund may be made by the learner at any time without limitations before, during, or after course participation.

Concussion Management

Live Interactive Webinar

Presented By: Sara Ziegele, PT, DPT, OCS

Contact: sara@bepreemptive.com

Course Overview

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Disclaimer

- Application of concepts presented in this webinar is at the discretion of the individual participant in accordance with federal, state, and professional regulations
- No conflict of interest exists for the presenter or provider of this course

Course Schedule: 3 Hr Live Webinar

Topic	Time
Introduction	0:00-0:05
Epidemiology	0:06-0:10
Risk factors	0:10-0:25
Anatomy	0:26-0:30
Injury mechanism	0:30-0:40
Interactive Discussion of Clinical Applications	0:41-1:00
Diagnosis	1:01-1:05
Symptom presentation	1:06-1:10
Evaluation: Autonomic	1:11-1:20
Evaluation: Cervical	1:21-1:25
Evaluation: Vestibular and oculomotor	1:26-1:30
Evaluation: Motor function	1:30-1:40
Evaluation: Mental	1:41-1:45
Evaluation: Cognition	1:46-1:50
Interactive Discussion of Clinical Applications	1:51-2:00
Treatment principles	2:01-2:10
Impairment based treatment	2:11-2:20
Adapted treatments	2:20-2:30
Medical clearance and return to sport	2:31-2:40
Prognosis	2:41-2:50
Interactive Discussion of Clinical Applications	2:51-3:00

Course Post-Test

- Slides with "Consider This" icon in corner will be helpful in completing the post-test

Consider This

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Definitions

- Concussion or mild traumatic brain injury (mTBI)
 - Transmission of mechanical energy due to a blow to the head, neck, or body that results in disruption of brain function
 - No apparent structural damage on a CT scan or brain MRI
 - Glasgow Coma Scale 13-15
- Structural injuries (ie. brain bleeding, swelling, skull fracture) would classify as more severe traumatic brain injury

Glasgow Coma Scale

Behavior	Response	
Eye opening	Spontaneously	4
	To speech	3
	To pain	2
Verbal	No response	1
	Oriented to time, place, person	5
	Confused	4
	Inappropriate words	3
	Incomprehensible sounds	2
Motor	No response	1
	Obeys commands	6
	Moves to localized pain	5
	Flexion withdrawal from pain	4
	Abnormal flexion	3
	Abnormal extension	2
	No response	1

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Definitions

- Concussion or mild traumatic brain injury (mTBI)

≥1 of the following signs



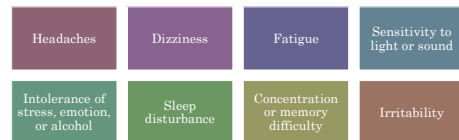
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Definitions

- Post concussive syndrome
 - Persistence of concussion symptoms beyond expected duration for recovery
 - Recovery expected within 2-3 weeks
 - ≥4 weeks = persistent symptoms
 - Chronic condition consisting of a combination of symptoms



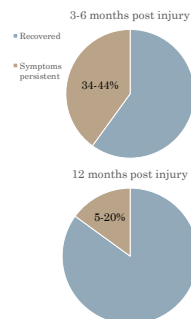
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Epidemiology

- Traumatic brain injuries are prominent worldwide
 - 64.74 million new cases annually
- 70-90% of them are mTBI
 - 2 million new concussions annually in the United States



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Epidemiology

- Leading causes
 - Sports*
 - In order of risk
 - Rugby
 - American football
 - Ice hockey
 - Wrestling
 - College > high school
 - Games > practice
 - Assaults*
 - Motor vehicle accidents
 - Bicycle accidents
 - Falls



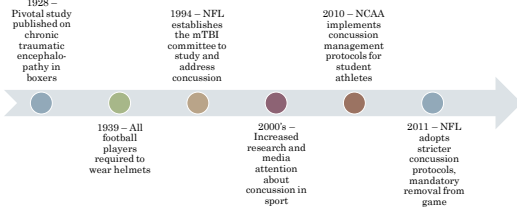
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Epidemiology

- Evolution of concussion awareness



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Risk Factors

- For prolonged recovery after concussion
 - Prior concussion
 - Older age
 - Attention deficit hyperactivity disorder
 - Anxiety
 - Symptom burden at time of injury
- Gender
 - Female athletes may be more susceptible to concussion, more likely to report concussion, and more likely to have prolonged symptoms
 - Hypotheses
 - Neck and head dimension and strength
 - Hormonal fluctuations



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Anatomy

- **Brain**
 - Weighs 3# in average adult
 - Composition
 - 60% fat
 - 40% water, protein, carbohydrates, salts
 - Contains blood vessels and nerves
 - Neurons
 - Transmit signals
 - Glial cells
 - Provide structural support and protect neurons, maintain the brain's environment, and produce myelin



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Anatomy

- Brain
 - Gray matter
 - Outer portion of the brain
 - Contains neuronal cell bodies, dendrites, glial cells, axons, and synapses
 - Produces neuronal signals
 - White matter
 - Inner section of the brain
 - Contains myelinated and unmyelinated neuronal axons
 - Physical connection between neuronal cell bodies that transmits the neuronal signals efficiently between gray matter regions

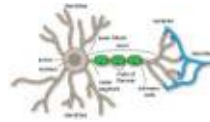


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Anatomy

- Brain
 - Cerebrum
 - The largest part of the brain
 - Outer, gray matter portion is the cerebral cortex
 - Separated into left and right hemispheres
 - Hemispheres join at the interhemispheric fissure
 - Communicate through the large structure of white matter and nerve pathway called the corpus callosum
 - Four lobes in each hemisphere (frontal, temporal, parietal, occipital)
 - Inner, white matter



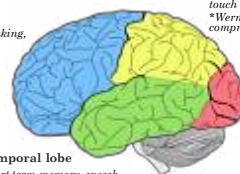
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Anatomy

- Lobes of the cerebral cortex

- Frontal lobe**
Personality, decision making, movement
**Broca's area: speech*



Parietal lobe
Object identification, spatial relationships, interpreting pain & touch
*Wernicke's area: speech comprehension

Occipital lobe
Vision

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Anatomy

- Brain

- Sex differences in the cerebrum

Male

Structure

Tend to have fewer but thicker myelinated fibers crossing the corpus callosum

Function

Tend to be more lateralized, using single hemisphere to accomplish tasks

Female

Structure

Tend to have greater number but smaller diameter fibers

Function

Tend to make greater use of both hemispheres, traversing larger area of brain



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Anatomy

- Brain

- Brainstem
 - Connects cerebrum and spinal cord
 - Includes the midbrain, pons, medulla
 - Maintains functions necessary for life such as breathing, consciousness, maintaining blood pressure, heart rate, and sleep regulation

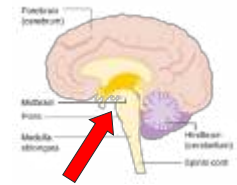


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Anatomy

- Brain

- Cerebellum “little brain”
 - Located at the back of the head, above the brainstem
 - Functions to coordinate voluntary muscle movement and maintain posture, balance, and equilibrium

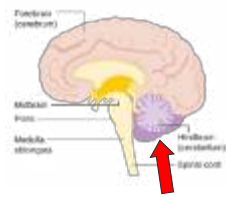


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Anatomy

- Deeper Structures Within the Brain

Pituitary Gland	Hypothalamus	Amygdala	Hippocampus	Pineal Gland
Governs function of other glands, regulates hormones from thyroid, adrenals, ovaries and testes	Sends messages to pituitary. Regulates body temp, sleep, hunger and thirst, role in memory and emotion	Regulates emotion and memory, reward system, stress, and the "fight or flight" response	Supports memory, learning, navigation, spatial perception. Receives info from cerebral cortex	Responds to light and dark, secretes melatonin for circadian rhythm and sleep-wake cycle

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Anatomy

- Protective covering called meninges surrounds the brain and spinal cord

- Dura mater
 - Outermost layer
 - Thick and tough
- Arachnoid mater
 - Thin, weblike
 - Below arachnoid is the cerebrospinal fluid cushion
- Pia mater
 - Thin membrane that hugs surface of brain

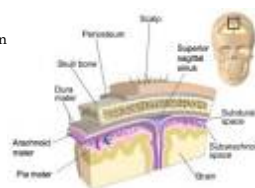


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Anatomy

- **Circulation**
 - Blood supply and oxygen supplied by two sets of vessels
 - Vertebral arteries
 - Supplies rear portion of brain
 - Carotid arteries
 - Supplies front portion of brain
 - Circle of Willis
 - Loop of blood vessels that connects major arteries and circulates blood between front and rear

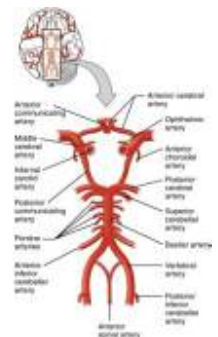


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Anatomy

• 12 Cranial nerves

1: Olfactory (smell)	2: Optic nerve (eyesight)	3: Oculomotor (pupil response, eye motions)	4: Trochlear (eye muscles)
5: Trigeminal (sensory from scalp, teeth, jaw, sinus, mouth, face and motor for chewing)	6: Abducens (eye muscles)	7: Facial (face movement, taste, gland function)	8: Vestibulocochlear (balance and hearing)
9: Glossopharyngeal (taste, ear and throat movement)	10: Vagus (sensation for ear and digestive, motor for heart, throat and digestive)	11: Accessory (muscles in head, neck, shoulder)	12: Hypoglossal (motor to tongue)

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Anatomy

• Vestibular system

- Peripheral components (inner ear)
 - Two functional units with different neuronal circuitry (*see below*)
- Central components
 - Connections to the brain stem, cerebellum, cerebral cortex, visual system, postural muscles

Vestibulo-ocular system	Vestibulo-spinal system
<ul style="list-style-type: none"> • Maintain visual stability during head and body movements • Vestibulo ocular reflex • Semicircular canals (3) • Sensitive to rotational acceleration in all directions of space 	<ul style="list-style-type: none"> • Postural control • Otoliths (utricle and saccule) • Sensitive to gravitational and linear acceleration

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Anatomy

• Ocular system

- Every eye movement has a different neural pathway with connections to other sensory systems
 - Allows brain to constantly monitor oculomotor performance
 - Adjusts according to changes in head/body position and visual environment
- Distinct pathways initiate different eye movements
 - Horizontally
 - Vertically
 - Coordination of both eyes moving from one distance to another
- The complexities of these pathways are still not fully understood



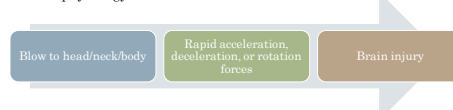
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Mechanism of Injury

• Pathophysiology



- Forces produce significant shearing and tearing of tissue (white matter axons and small blood vessels) called diffuse axonal injury
- Axons tolerate stretching of up to twice their resting length during daily activity
- Rapid deformation causes the axon to become stiffer, brittle, and more injury prone

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Mechanism of Injury

• Pathophysiology

- Triggers a cascade of neurometabolic changes
 - On molecular or microvascular scale
 - Ionic dysregulation of sodium-potassium
 - Impaired neurotransmission along axons
 - Decreased cerebral blood flow or neurovascular uncoupling
- Symptom provocation
 - Result of impaired efficiency of the brain in increasing blood supply to networks that are best suited to task demands



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Mechanism of Injury

• Pathophysiology

- Neuroimaging studies identified neurometabolic disruption of the emotional circuitry after concussion
- Alterations are similar to those seen in clinical depression
- Unclear whether these changes resolve upon symptom resolution or persist for weeks/months



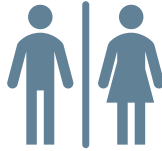
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Mechanism of Injury

- **Sex differences**
 - Forces resulting in concussion often produce greater shear and strain in the corpus callosum
 - Can lead to axonal damage and a greater number of and more concussion symptoms
 - Males may be able to withstand larger axonal stresses due to larger cross-sectional area, larger fiber diameter, and greater number of microtubules in the axon of corpus callosum
 - Disruption to this neural network from axonal strain may lead to greater symptoms in females due to increased reliance of interhemispheric connections



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Mechanism of Injury

- Vestibular dysfunction
 - Mismatch between visual information and other sensory motor feedback systems can cause an image to falsely appear as if it is moving or shifting
 - Vestibulo ocular reflex is independent of visually mediated eye movements (ie. saccades, pursuits, vergence, accommodation)



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Mechanism of Injury

- **Ocular dysfunction**
 - Since every eye movement has a distinct neural pathway, post-concussion symptoms can vary significantly
 - Can occur with one or more eye movements
 - Can occur in one or multiple directions
 - Symptoms may not be classically linked to a visual etiology

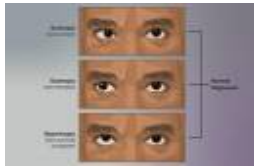


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Mechanism of Injury

- **Cervical dysfunction**
 - Whiplash impact on cervical muscles and the nerve roots
 - Impaired cervical proprioception
 - Compromised ability to synchronize with vestibulo ocular and optokinetic reflexes to maintain a visual target during head movements
 - Tightening of neck muscles from cervical root irritation
 - Limits neck ROM and convergence mechanisms resulting in double vision, dizziness, lightheadedness, and imbalance



Image: Injury Map Neck pain

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Mechanism of Injury

- Autonomic dysfunction
 - Peripheral involvement
 - Sympathetic nerve supply is located throughout the cervical spine
 - Vulnerable to trauma of the neck
 - Injury can lead to dysregulation
 - May result in tachycardia and blood pressure fluctuation
- Central involvement
 - Dysregulation of cerebral blood flow

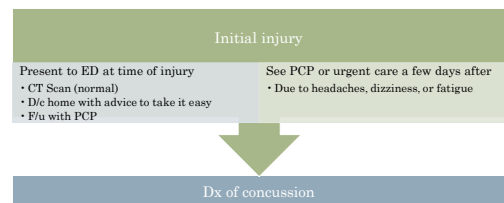


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Diagnosis

- Common diagnosis pathway



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Diagnosis

- Acute phase (<3 days post injury)
 - Goals
 - Protect patient from further injury
 - Removal from play or high-risk activity
 - Quickly evaluate the patient and rule out more serious injury
 - Cervical injury
 - Skull fracture
 - Intracranial hemorrhage



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Diagnosis

- Acute phase (<3 days post injury), *cont'd*
 - On-field assessments developed by the Concussion in Sport Group
 - Concussion Recognition Tool 5 (CRT5)**
 - For identification of suspected concussion by non-medical professionals
 - If concussion suspected, athlete should be removed from practice or play and not returned until assessed medically
 - Step 1: Red flags** – call an ambulance if no licensed healthcare professional is available

Neck pain or tenderness	Severe or increasing HA	Deteriorating conscious state
Double vision	Seizure or convulsions	Vomiting
Weakness or tingling/burning in arms or legs	Loss of consciousness	Increasingly restless, agitated or combative

https://pmc.ncbi.nlm.nih.gov/articles/PMID/25043853/figure-2011-07/PMC3875_full.pdf

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Diagnosis

- Acute phase (<3 days post injury), *cont'd*
 - Concussion Recognition Tool 5 (CRT5)**
 - Step 2: Observable signs

Lying motionless on the playing surface	Disorientation or confusion, or an inability to respond appropriately to questions	Balance, gait difficulties, motor incoordination, stumbling, slow labored movements
Slow to get up after a direct or indirect hit to the head	Blank or vacant look	Facial injury after head trauma

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Diagnosis

- Acute phase (<3 days post injury), *cont'd*
 - Concussion Recognition Tool 5 (CRT5)**
 - Step 3: Symptoms

HA	Blurred vision	More emotional	Difficulty concentrating
Pressure in head	Sensitivity to light	More irritable	Difficulty remembering
Balance problems	Sensitivity to noise	Sadness	Feeling like in a fog
Nausea or vomiting	Fatigue or low energy	Nervous or anxious	Feeling slowed down
Drowsiness	Don't feel right	Neck pain	
Dizziness			

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Diagnosis

- Acute phase (<3 days post injury), *cont'd*
 - Concussion Recognition Tool 5 (CRT5)**
 - Step 4: Memory assessment (older than 12 y/o)

Failure to answer any of these questions (modified appropriately for each sport) correctly may suggest a concussion:	What venue are we at today?	What team did you play last week/game?
	Which half is it now?	Did your team win the last game?
	Who scored last in this game?	

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Diagnosis

- Acute phase (<3 days post injury), *cont'd*
 - Sport Concussion Assessment Tool 5th edition (SCAT5)**
 - For medical professionals
 - Cannot be performed in <10 minutes
 - Baseline testing can be performed but is not required
 - Step 1: Immediate or on-field assessment**
 - Red flags (same as CRT5)
 - Observable signs (same as CRT5)
 - Memory assessment Maddocks Questions (same as CRT5)
 - Glasgow Coma Scale
 - Cervical spine assessment

Does the athlete report that their neck is pain free at rest?	If there is not neck pain at rest, does the athlete have a full range of active pain free movement?	Is the limb strength and sensation normal?
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Diagnosis

- Acute phase (<3 days post injury), *cont'd*
 - Sport Concussion Assessment Tool 5th edition (SCAT5)
 - Step 2: Symptom evaluation
 - List very similar to CRT5
 - Step 3: Cognitive screening
 - Orientation
 - Immediate memory (5 word and 10 word lists)
 - Concentration
 - Digits backwards
 - Months in reverse order

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Diagnosis

- Acute phase (<3 days post injury), *cont'd*
 - Sport Concussion Assessment Tool 5th edition (SCAT5)
 - Step 4: Neurological screen
 - Modified Balance Error Scoring System (mBESS)

Can the patient read aloud and follow instructions without difficulty?	Does the patient have a full range of pain-free passive cervical spine movement?	Without moving their head or neck, can the patient look side to side and up and down without double vision?
Can the patient perform the finger nose coordination test normally?	Can then patient perform tandem gait normally?	

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Diagnosis

- Acute phase (<3 days post injury), *cont'd*
 - Sport Concussion Assessment Tool 5th edition (SCAT5)
 - Step 5: Delayed recall
 - Same list as immediate recall, but 5 min later
 - Step 6: Decision
 - Section scoring
 - Clinical decision



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Diagnosis

- Subacute phase (>3 days post injury)
 - Goals
 - Provide appropriate concussion management
 - Minimize extent and duration of morbidity
 - May include the following
 - Further medical assessment
 - Recommendations for school, work, sport participation
 - Generalized activity prescription
 - Interventions including therapy and medications

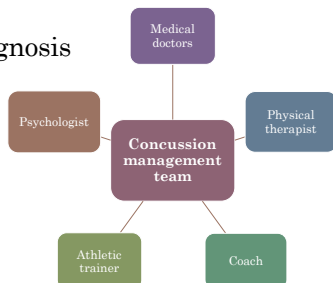


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Diagnosis



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Diagnosis

- Diagnostic testing: structural imaging
 - Routine imaging (head CT, brain MRI) and electrophysiologic studies (EEG) do not have much diagnostic value
 - Can reassure patient that no structural damage occurred
 - Cervical imaging
 - Radiographs can be considered for spine issues
 - Rarely show evidence of injury from mild TBI or whiplash injury
 - Can identify cervical spondylosis
 - Cervical spine MRI indications
 - Myelopathic features
 - Active radiculopathy sx including severe shooting pains and extremity weakness



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Diagnosis

- Diagnostic testing: functional imaging
 - Promising for future clinical use, but currently limited to research at specialized centers
 - Functional imaging modalities (MRI)
 - Quantitative Electroencephalography (QEEG)
 - Neurophysiological tests
 - Barriers to utilization
 - Time required for testing
 - Cost
 - Accessibility
 - Lack of standardized protocols
 - Wide variability in results

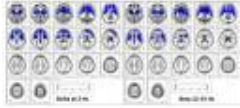


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http://monoceros.scripps.edu/PDFs/LOHETA_qEEG_in_a_person_with_ME-CPB.pdf

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Diagnosis

- Diagnostic testing: biomarkers
 - Biofluid biomarkers of injury to various neurological structures
 - Astroglial injury
 - Neuronal cell body injury
 - Axonal injury
 - Measured in blood or cerebrospinal fluid
 - Most studied is S100-B
 - Could possibly have future role in management
 - At time of injury, to indicate severity, to monitor recovery



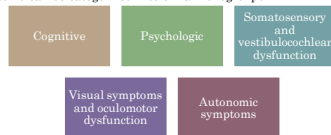
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Symptom Presentation

- Symptoms can be categorized into 5 main subgroups



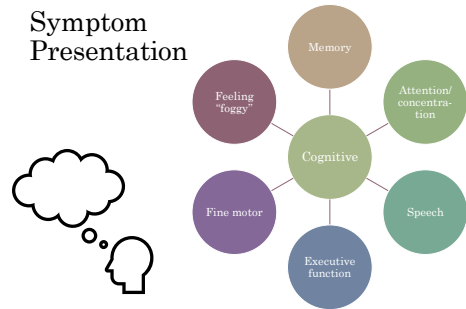
- Headache and neck pain may be the only initial symptoms
 - Post-traumatic headache is the most common and long-lasting symptom
 - >50% will continue to have headaches a year after injury
- Other symptoms may take a few days to a week to develop

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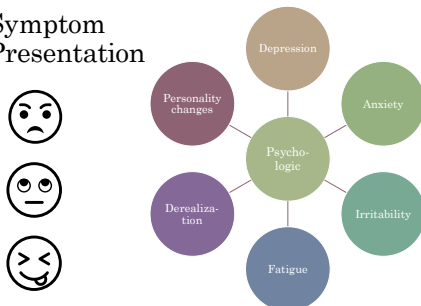
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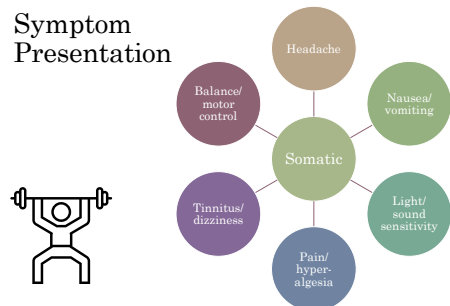
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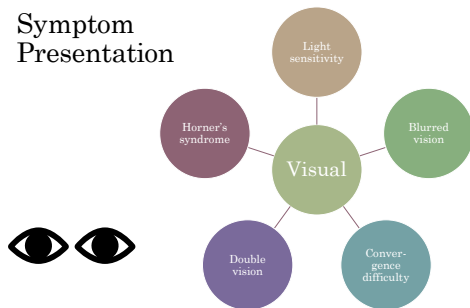
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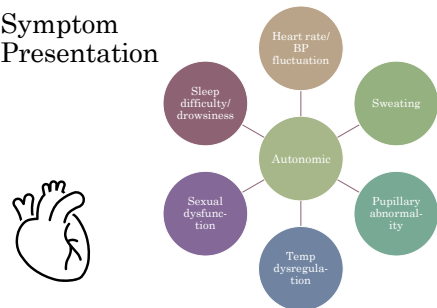
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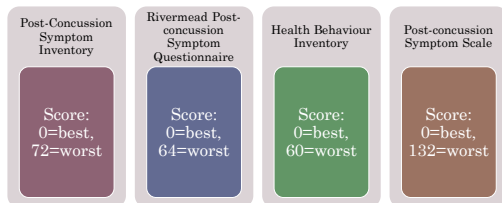
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Evaluation: Symptom scales



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Evaluation: Cognitive

- Neurocognitive testing
 - Particularly helpful when patients are not forthcoming about their symptoms
 - ImPACT testing (immediate post-concussion assessment and cognitive testing)
 - Often administered by athletic trainer
 - Takes about 20 min to complete
 - Computerized
 - Comprehensive neurocognitive testing
 - Administered by neuropsychologist
 - Takes hours or days to complete
 - Combination of computerized, paper/pencil, interviews



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Evaluation: Psychologic/Mood

- Symptoms can be difficult to differentiate due to overlap with other symptoms
 - Example: dizziness and nausea are common symptoms of both anxiety and vestibular dysfunction
- Concussion symptom inventories can screen for mood related impairment
- Thorough evaluation requires more in-depth interview regarding mood and stressors
 - No concussion specific tools available

Psychology Assessment Tools

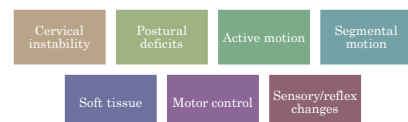
- Brief Symptom Inventory
- Beck Anxiety Inventory
- Beck Depression Inventory
- Brief Symptom Inventory 18
- Center for Epidemiologic Studies Depression Scale

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Evaluation: Somatic/Cervical

- Patient-reported outcome measures can help identify cervicogenic symptoms for further evaluation
 - Neck Disability Index
 - Dizziness Handicap Inventory
- Components of the cervical evaluation



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Evaluation: Somatic/Cervical

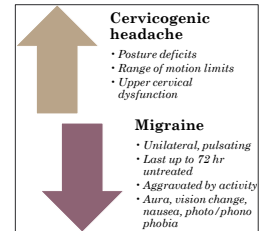
Cervical instability	Sharp-Purser test, transverse ligament stress test, cervical flexion-rotation test
Postural deficits	Baseline vs acquired, structural vs functional
Active motion	Cardinal planes, quadrants
Segmental motion	Joint play assessments: central and unilateral, cervical and thoracic
Soft tissue	General tissue extensibility, localized trigger points
Motor control	Craniocervical flexion test, cervical proprioception, balance
Sensory/reflex changes	Dermatome testing, Hoffmann's sign

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Evaluation: Somatic/Cervical

- Differentiating cervicogenic sources of headache vs migraine
- Migraine is associated with worse clinical course and requires distinct management (medication, trigger identification)
- More severe symptoms
- Increased neurocognitive deficits
- Protracted recovery



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Evaluation: Somatic/Cervical

- Differentiating cervicogenic sources of dizziness
- Consider when dizziness has specific pattern
 - Episodic
 - Close temporal relationship to neck pain
 - Provoked by neck movements or positions (rather than whole-body movements)
- Testing
 - Involves movement of the body with a stable head
 - Activates cervical spine while eliminating vestibular influences
 - Cervical relocation testing (cervical proprioception) may also help differentiate



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Evaluation: Somatic/Motor Function

- Objective clinical balance impairments often recover quickly within 3-5 days
- Testing may look different based on time since injury
 - Acute (≤ 3 days)
 - Balance Error Scoring System (BESS)
 - Sensitivity 35%, specificity 91-96%

Double leg stance (floor)	Non-dominant SLS (floor)	Tandem, non-dominant back (floor)
Double leg stance (foam)	Non-dominant SLS (foam)	Tandem, non-dominant back (foam)
Errors: move hands off iliac crest, open eyes, step/stumble/fall, ABD or flex hip >30 deg, lift forefoot or heel off floor, out of test position >5 sec		
Scoring: 20 sec in each position, 1 point deduction per error with maximum of 10 points per condition, worst possible score 60 points		

- Subacute
- Dual task balance

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Evaluation: Somatic/Vestibular & Visual/Oculomotor

Consider This

- Vestibular/Ocular Motor Screening tool (VOMS)
 - Standardized assessment to identify potential vestibular and oculomotor dysfunction related to concussion
 - Record baseline symptoms for headache, dizziness, nausea, and foggy on 0 (none) to 10 (severe) scale
 - Perform assessment for the first domain
 - Re-assess and record symptom score
 - Repeat until all five domains are assessed
 - Score cutoffs for increased likelihood of concussion
 - ≥ 2 on individual VOMS items
 - or near point of convergence >5 cm



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Evaluation: Somatic/Vestibular & Visual/Oculomotor

- VOMS
- Smooth pursuit (ocular)
 - Conjugate eye movement allowing both eyes to simultaneously follow a slow-moving target, maintains image on the retina
 - Works with VOR for target fixation when head and body is in motion
 - Symptoms specific to smooth pursuit dysfunction
 - Visual motion sensitivity
 - Sick when following moving targets (traffic, watching movies)
 - Difficulty scrolling on screens



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Evaluation: Somatic/Vestibular & Visual/Oculomotor

· VOMS

- Smooth pursuit (ocular)
 - Hold a fingertip 3 ft. from the patient. Patient maintains focus on finger as it moves smoothly 1.5 ft. horizontally to each side. Movement should take 2 seconds from right to left. Perform 2 reps
 - Repeat vertically
- Dysfunction
 - Eyes lose track of the moving object and use a saccadic eye-movement to recover or "catch up"
 - Makes abnormal smooth pursuits look jerky



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Evaluation: Somatic/Vestibular & Visual/Oculomotor

· VOMS

- Saccades (ocular)
 - Conjugate eye movement allowing both eyes to move quickly in same direction, rapidly shifting eyes between objects
 - Voluntary or reflexive to visual, auditory, memory, or tactile stimuli
 - Symptoms specific to saccadic dysfunction
 - Dizziness with eye movements
 - HA or losing their place with reading
 - Eyestrain
 - Re-reading
 - Difficulty with eye contact
 - Difficulty reading on screens
 - Sx watching fast moving objects



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Evaluation: Somatic/Vestibular & Visual/Oculomotor

· VOMS

- Saccades (ocular)
 - Hold two fingertips horizontally 3 ft. from patient and 1.5 ft. to each side of midline (patient must gaze 30° each direction)
 - Instruct patient to move their eyes as quickly as possible from point to point for 10 repetitions, record sx score
 - Repeat vertically
- Dysfunction
 - Hypometric: undershoot target
 - Hypermetric: overshoot target
 - Slower velocity/increased latency
 - Smaller peak acceleration



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Evaluation: Somatic/Vestibular & Visual/Oculomotor

· VOMS

- Vergence (ocular)
 - Disconjugate eye movement to track an object moving closer or further away
 - As object moves further away, both eyes move outwards (divergence)
 - As object moves closer, both eyes move inwards (convergence)
 - Both eyes need to move the same speed and magnitude for binocular vision
 - If not, double or blurry vision occurs
 - Symptoms specific to vergence dysfunction
 - Losing one's place while reading
 - Double vision
 - Eyestrain
 - Fatigue



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Evaluation: Somatic/Vestibular & Visual/Oculomotor

· VOMS

- Vergence (ocular)
 - Patient focuses on a small target (such as a pen) at arm's length and slowly brings it toward the tip of their nose
 - Instruct patient to stop moving the target when they see two distinct images or when outward deviation of one eye is observed
 - Measure distance between object and tip of nose
 - Repeat x3
- Dysfunction
 - Near point convergence <5 cm



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Evaluation: Somatic/Vestibular & Visual/Oculomotor

· VOMS

- Vestibulo ocular reflex/VOR (vestibular)
 - Ability to stabilize vision as the head moves
 - Compensatory eye movements are triggered in the opposite direction of head rotation
 - Symptoms specific to VOR dysfunction
 - Nausea
 - Imbalance
 - Dizziness
 - Movement-related blurry vision
 - Unsteadiness
 - Vertigo
 - Anxiety in busy environments
 - Visual motion sensitivity



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Evaluation: Somatic/Vestibular & Visual/Oculomotor

• VOMS

- Vestibulo ocular reflex/VOR (vestibular)
 - Hold a target (such as a pen) 3 ft from the patient at midline
 - Instruct patient to rotate their head horizontally 20° to each side while focusing on target, at pace of 180 beats per minute on metronome
 - Repeat x10 repetitions
 - Repeat vertically
- Dysfunction
 - Symptom report
 - Decreased pace



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Evaluation: Somatic/Vestibular & Visual/Oculomotor

• VOMS

- Motion sensitivity (vestibular)
 - Also known as VOR cancellation
 - Ability to inhibit vestibular-induced eye movements using vision
 - Brain requires accurate, stable smooth pursuits and vestibular input to process visual motion and motion parallax
 - After concussion, over-reliance on the visual system can result in heightened awareness of visual motion



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Evaluation: Somatic/Vestibular & Visual/Oculomotor

• VOMS

- Motion sensitivity (vestibular)
 - Patient stands with arms outstretched, facing a busy area (guard patient in case of balance issue)
 - Focusing on thumb, patient rotates (head, eyes, and trunk together as a unit) 80° each direction, at pace of 50 bpm on metronome
 - Repeat x5 reps
- Dysfunction
 - Symptom report
 - Decreased pace



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Evaluation: Somatic/Vestibular

• Additional testing: BPPV

- Benign paroxysmal positional vertigo (BPPV)
 - When one or more of the calcium carbonate crystals in the utricle become dislodged and migrate into a semi-circular canal
 - Produced by changes in the position of the head in relationship to gravity, lasting for a short duration of symptoms
- Testing
 - Dix-Hallpike – posterior semicircular
 - Supine roll tests – horizontal



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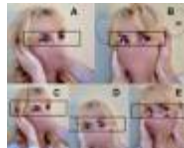
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Evaluation: Somatic/Vestibular

• Advanced vestibular testing

- Vestibular specialist may employ additional tests
 - Dynamic visual acuity test
 - Head impulse test
 - Head-shake nystagmus test
- May require specialized equipment



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Evaluation: Visual/Oculomotor

• Additional testing: accommodation

- Ability for each eye to individually flex the intraocular lens and produce a clear image onto the retina
- The amount of accommodation or visual clarity/"focus" depends on how close the object is to the eye
 - Closer object = more accommodation



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Evaluation: Visual/Oculomotor

- Additional testing: fixation
 - Ability to voluntarily maintain eye alignment on any given target
 - Active and complex neurological process termed fixation which requires the activation of multiple eye movements including micro-saccades, accommodation, and vergences



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Evaluation: Visual/Oculomotor

When to refer out: To neuro-ophthalmology or neuro-optometry

New difference in pupil size	Vertical diplopia
Direction-changing nystagmus	Visual field cuts
Overshooting with saccades	+ head shake test
Saccades during VOR cancellation	Large convergence insufficiency
Head tremors	Convergence spasm
Ptoxis	Large phorias/tropias
Persistent head tilt	
Skew deviation	

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Evaluation: Visual/Oculomotor

When to refer out: To ophthalmology or optometry

Direct trauma to eye	Flashes of light
Floater	Eye pain
Missing vision in one eye	Persistent photophobia

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Evaluation: Autonomic

- Autonomic nervous system dysfunction can be assessed with tools and measures of exercise tolerance
 - Gradually increase workload while measuring heart rate and blood pressure
 - Continue until the first sign of symptom exacerbation
 - Commonly used protocols
 - Buffalo Concussion Treadmill Test
 - Balke Cardiac Treadmill Stress Test
 - McMaster All-Out Progressive Continuous Cycling Test



Consider This

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Evaluation: Autonomic

- Buffalo treadmill test
 - Continue progression until one of the following
 - Participant reaches max HR or RPE 19 (exhaustion)
 - Sx increase by ≥ 3 points (new symptom or increased symptom load) on the Likert scale (symptom exacerbation)

Stage	Speed	Incline	RPE	HR	Symptoms
0	3.2 mph	0.0%			
1		1%			
2		2%			
3		3%			
4		4%			
5		5%			
6		6%			
7		7%			
8		8%			
9		9%			
10		10%			
11		11%			
12		12%			
13		13%			
14		14%			
15		15%			
16	3.6 mph	15%			
17	4.0 mph				
18	4.0 mph				
19	4.8 mph				
20	5.2 mph				

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Treatment Principles

- Evolution of post concussion management
 - Historically, full physical and mental rest was often recommended
 - Dark room for days to weeks
 - Found to be unnecessary and harmful
 - Increased anxiety
 - Perseveration on symptoms
 - No longer a passive injury
 - Concussion is now considered treatable
 - Active/targeted rehabilitation has better outcomes than prescribed rest alone



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Treatment Principles

- The role of rest
 - Quality sleep and rest are critical to prevent and treat post concussion syndrome
 - Generally advised to rest for 48 hours after head injury
 - Includes both physical and cognitive rest
 - Long-term rest is discouraged
 - Insufficient rest in the acute period may lead to increased metabolic demand of the brain before it has had a chance to recover



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Treatment Principles

- The role of rest
 - Prolonged, strict physical inactivity can lead to secondary symptoms, including depression, anxiety, and fatigue
 - Routine, light daily activities are needed to maintain baseline function
 - Active patients may require more activity
 - Early reintroduction of activity in children/adolescents within a week may reduce post concussive syndrome
 - Aerobic exercises and exercises with vigorous head/neck movements should be avoided



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Treatment Principles

- The role of rest (physical)
 - Brain recovers with sufficient rest and sleep
 - Reorganization is facilitated by deeper stages of sleep
 - Sleep quality is often impaired after concussion
 - Sleep aids may be beneficial (melatonin, sleep music, white noise)
 - Indicator of quality sleep: waking refreshed
 - A regular sleep schedule can help stabilize a deranged circadian rhythm
 - Afternoon naps may be valuable



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Treatment Principles

- The role of rest (cognitive)
 - Dosing cognitive load is needed until the brain is ready
 - Patients commonly push themselves, hoping for an early recovery – counterproductive
 - Tasks should be stopped as soon as fatigue sets in
 - Fatigue is indicative of the cognitive or physical limit
 - Time to fatigue can be an effective marker for the recovery process
 - Steady improvement in work capacity and a longer "time to fatigue" is an encouraging sign of recovery



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Consider This

Treatment Principles

- Behavioral modifications
 - Setting a routine for daily activities can help restore normalcy in the brain
 - Regular wake and sleep times can establish a schedule

Behaviors to AVOID

- Stimulants (ex: caffeine) in evening
- Alcohol and CNS depressants at all times
- Social gatherings
- Loud environments
- Chaotic music
- Prolonged screen time (TV, computers, phones)

Behaviors to ENCOURAGE

- Walks outside in calm environment
- Gentle instrumental music
- Light reading from paper or books

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Treatment Principles

- Timing of intervention
 - Median time for referral to rehab: 53-61 days post injury
 - Early management is preferable
 - Studies of pediatric, adolescent, and young adult athletes suggest benefits of initiating clinical care and rehab earlier (within 7 days) rather than later (at 8-20 days)
 - Reduced symptoms
 - Reduced time to recovery
 - Improved function
 - When early management is not feasible, patients with symptoms that do not resolve within 4 weeks should be evaluated further



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Treatment Principles

- **Timing of intervention**
 - It is never too later to refer a patient for vestibular and vision rehab
 - Studies have shown improvement in symptom severity, mental and physical health even in chronic mTBI
 - Studied in populations up to 3 years after sx onset
- **Progressive, targeted interventions that match the clinical profile**
 - Improvement achieved across systems
 - Total sx burden, verbal memory, smooth pursuit, VOR, motion sensitivity, convergence, balance



Consider This

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Treatment: Cognitive

- Temporary accommodations for work/school can help maintain good standing without penalty
 - Graduated return to school progression
 - Daily activities only → school activities outside the classroom → part time school → full time school

Potential Accommodations

- Shorter school days
- More time for tests/ assignments
- Quiet room to work
- Avoiding noisy areas (cafeteria, music class, etc)
- Taking breaks
- Daily test limits
- Memory cues
- Shorter assignments
- Student helper/ tutor
- Teacher reassurance

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Treatment: Psychologic/Mood

- **Cognitive behavioral therapy**
 - Useful for mood disorders related to concussion
- Breathing and meditation exercises
 - Improve autonomic regulation
 - Enhance attention
- Create psychological environment conducive to recovery



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Treatment: Somatic/Cervical

- Address dysfunction of cervical and thoracic spine
 - Strength
 - Range of motion
 - Postural position
- Sensorimotor function
 - Cervicocephalic kinesthesia
 - Head position control
 - Cervical muscle dysfunction
- Manual therapy
 - Graded cervical manual therapy has been shown to speed up symptom resolution and medical clearance



Reinhart, A., Bialle, R.E., Alshewhry, M.S., Gorman, A.P., Alkhatib, R.A., Raharjeng, V.N., Ahmed, I., Kandel, P.R., AlMubina, M.A. A Cross-Sectional Study on Mediating Effect of Chronic Pain on the Relationship between Cervical Proprioception and Postural Balance in Elderly Individuals with Chronic Neck Pain: Mediation Analysis Study. *J. Clin. Med.* 2023;12, 3340. <https://doi.org/10.3390/jcm12053340>

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Treatment: Somatic/Motor Function

- **Balance**
 - Static balance
 - Stable surface
 - Unstable surface
 - With head movement
 - Dynamic balance
 - Tandem walking
 - Lunging to balance ball
 - Single leg RDL
- Motor coordination and control
 - Contralateral/ipsilateral marching
- Dual/multitasking
 - Add counting, categorical naming
- Functional tasks with carryover to work demands or recreational activities



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Treatment: Somatic/Vestibular & Visual/Oculomotor

- VOMS impairments become the treatment program
 - Exam techniques become the exercises
 - Smooth pursuit, saccades, vergence, VOR, visual motion sensitivity

Duration: Repeat until you are somewhat dizzy or eyes are tired, **WITHOUT** increasing headache
Frequency: At least 2x/day – progress to 5x/day

- Start slowly, gradually increase how many you are doing and how quickly you are doing them. It is more important to keep the target focused than to go fast or for a long time.
- Some mild dizziness or discomfort is okay, but it should go away relatively quickly after resting. Stop and resume at a later time if your headache begins to increase.

Wait until symptoms return to baseline before resuming exercises

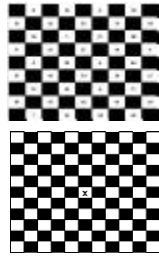
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Treatment:

• Environmental progressions

White wall → decorated wall → checkerboard	Quiet room → background noise → busy room
Stable surface → narrow stance → unstable surface	Stationary → while walking



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Treatment: Somatic/Vestibular

• BPPV

- Canalith repositioning
 - Posterior semicircular: Epley's maneuver
 - Horizontal: BBQ roll or Gufoni maneuver
- Recheck symptoms and repeat as needed
- Follow with HEP

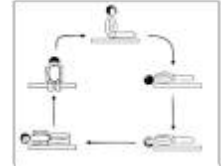


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Treatment: Autonomic

- Exercise improves cerebrovascular autoregulation
 - Daily exercise below symptom threshold can facilitate neurologic adaptations to exercise
 - Decreases exercise-related symptoms
- Indications to use aerobic exercise training program

Exertional intolerance	Planning to return to vigorous activity	Fear-avoidance	Deconditioning
	To promote functional brain healing	Non-pharmaceutical option for mental health	

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Treatment: Autonomic

- Graded resumption of activity based on tolerance
 - Start with 5–10 min of aerobic exercises in the first week
 - Take into account patient age, physical, and psychological factors
 - Parameters and progressions
 - Subthreshold aerobic exercise (80%–90% HR of symptom onset)
 - Mode
 - Walking (treadmill vs outdoor)
 - Biking (stationary vs outdoor)
 - Elliptical



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Adjunct Treatments

• Medication

- Commonly used, but not the cornerstone of post concussion treatment
- There is no FDA-approved pharmacological treatment for concussion
 - Off-label use of medications that were approved for other primary purposes
- Medication is matched to the symptom subtype
 - Dose of medication needed at onset may be significantly higher than needed as the patient recovers
- Unless medication effects are identified and tapered early, they can slow recovery and mislead physicians



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Adjunct Treatments

• Medication

- Acetaminophen and NSAIDs
 - Mild-to moderate headache
- Medications such as butalbital/acetaminophen (Fioricet) and opioids should be avoided as it can cause worsening of cognitive issues and create dependence
- Propranolol
 - Headache prophylactic
 - Regulator of autonomic dysfunction
 - Use is often limited by worsening of depression, sexual dysfunction, and cardiovascular effects
- Cyclobenzaprine
 - Muscle relaxation and improved sleep



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Adjunct Treatments

- **Medication**
 - Gabapentin and amitriptyline
 - Nerve sensitivity
 - Amitriptyline also has antianxiety and antidepressant effects
 - Both have the potential for sedation
- Methylphenidate, Adderall, atomoxetine, amantadine
 - Antianxiety, antidepressants, and stimulants may be helpful in the acute phase
 - Sedative and dependence effects cause slowing of adaptation and clouding of clinical picture



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Adjunct Treatments

- **Cannabinoids**
 - Recreationally or medically for other comorbid conditions
 - Shown potential for treating individual symptoms associated with post concussion syndrome
- **Hyperbaric oxygen therapy**
 - Some evidence for improvement in cognition in patients with persistent post concussion syndrome, even in chronic phases
 - Not routinely available or used outside of tertiary care centers



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Adjunct Treatments

- **EEG biofeedback**
 - May reduce symptoms in patients who have not responded to conventional post concussion therapy
- Consumer EEG biofeedback devices are now available
 - Affordable, easy, and safe to use
 - May help train impaired attention networks
- **Brain stimulation techniques: transcranial direct current stimulation (tDCS)**
 - Research has shown it can boost attention in mild TBI patients when used along with intensive cognitive rehabilitation therapy



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Medical Clearance & Return to Sport

- **There are no objective measures or biomarkers of recovery from concussion**
 - Multidomain evaluation is the gold standard for determining recovery status
 - Verify normal, preinjury function
 - Provocation tests for neurocognitive function, exercise tolerance, and vestibular-oculomotor function
 - Compare to baseline testing when available
- Clinical recovery often does not align with physiological recovery
 - Abnormal electrical responses, metabolic balance, and oxygen consumption of neurons can persist several months after clinical testing normalizes and patients are symptom free



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Medical Clearance & Return to Sport

- **Benefit of normalizing vestibular and oculomotor function prior to return to sport**
 - Impairments are signs of neurologic impairment
- Elevated risk of reinjury during sport participation with persistent deficits
 - Danger of balance dysfunction or impaired gaze stabilization
- Consequences of chronic impairments from repetitive brain trauma



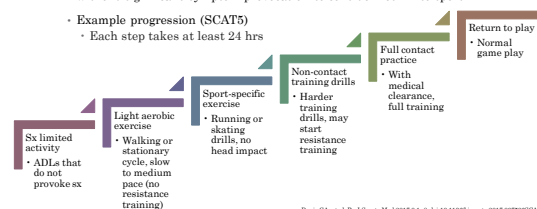
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Medical Clearance & Return to Sport

- Athletes need to be back to school full time without accommodations, without significant symptom provocation to consider return to sport
- **Example progression (SCAT5)**
 - Each step takes at least 24 hrs



Davis GA, et al. Br J Sports Med 2017;51:4. doi:10.1136/bjsports-2015-097888/SCAT5

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Prognosis

- Better outcomes are observed in concussed individuals with persistent symptoms (>2 weeks) who receive individually tailored multimodal interventions
 - Reduced symptoms
 - 3x more likely to return to sport by 8 weeks
- Most cases of central vestibular dysfunction and fixed peripheral vestibular disorders will resolve within 3 months



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Prognosis

- Up to 25% of patients with post concussive syndrome will experience symptoms >6 months (prolonged PCS)
 - Can lead to severe health effects
 - Mental health conditions
 - Anxiety
 - Depression
 - Suicidal ideation
 - Overall decreased quality of life
 - Increased risk of musculoskeletal injuries following return-to-play



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Prognosis

- Impact of repeat concussions
 - Second Impact Syndrome (SIS)
 - When a second concussion occurs before symptoms from the first concussion have resolved
 - Results in diffuse and often catastrophic cerebral edema
 - Very rare
 - Controversial diagnosis
 - Some experts argue that second impact syndrome is simply diffuse cerebral swelling unrelated to the first concussion



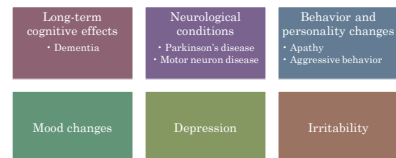
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Prognosis

- Impact of repeat concussions
 - Chronic traumatic encephalopathy (CTE)
 - Presentation



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Prognosis

- Impact of repeat concussions
 - Chronic traumatic encephalopathy (CTE)
 - Diagnosis
 - No agreed upon clinical diagnostic criteria due to the heterogeneity of presentation
 - Difficult to differentiate when it presents later in life and there are features of Alzheimer's disease

Consider This

Diagnostic Indicators

- Younger person (<50 y/o)
- History of concussion
- History of contact sport involving their head
- Presents with cognitive decline or behavioral change
- Neuroimaging shows evidence of damage

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Future Directions

- Prevention is the best medicine
 - Football
 - Practice contact restrictions
 - Limiting to 2 days/wk can reduce head impacts per player-season by 42%
 - Limiting to 75 min/wk (in week 2) and 60 min/wk (week 3 and beyond) reduced practice related concussion by 54%
 - "Heads Up Football"
 - Intervention focused on coach education and contact technique training
 - Positive results in high school football players
 - Reduced concussion rate by 32%
 - Reduced head impacts by 38%



Parkson M, P, Fitzpatrick R, A, Kolonel A, T, Hooten A, E, Danner C, R, Meek M, ... & Emery C, A. (2020). Head games: a systematic review and meta-analysis examining concussion and head impact incidence rates, modifiable risk factors, and prevention strategies in youth tackle football. *Sports medicine*, 50(5), 1259-1274. Image: iStockphoto

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Future Directions

- Prevention is the best medicine
 - Soccer
 - Heading coaching framework
 - Technical proficiency (Point of head contact, standing/ running/ jumping headers, body positioning for heading duels)
 - Emphasis on small sided games
 - Developing a rest and recovery strategy
 - Limiting headers from goal kicks and corners
 - Integration of neuromuscular neck exercises into injury reduction programs (such as FIFA 11 +)
 - Enforcement of rules related to head contact
 - Appropriate ball pressure



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Future Directions

- Helmet innovation
 - Position specific designs
 - Performance data available for players when making equipment decisions
 - Updated lists of approved helmets every season
- Other wearable devices
 - Mouth guards
 - Neck braces
 - Concussion headbands
 - Guardian caps
- Transforming player, coach, and public opinion regarding concussion



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Conclusion

- Post concussion syndrome is a prevalent condition amongst those with mild traumatic brain injury. Meaningful improvement in symptoms can be achieved when specially trained providers employ effective diagnostic strategies and targeted rehabilitation interventions. Continued research efforts will further enhance our understanding of concussion management.

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Q1

Which of the following is NOT one of the diagnostic criteria for concussion?

- A. Any alteration of mental state immediately after injury
- B. Posttraumatic amnesia for less than 24 hours
- C. Loss of consciousness for less than 5 minutes
- D. Other signs of focal and transient neurologic dysfunction

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Q2

Persistent (prolonged) symptoms of concussion are defined as those lasting for more than how many weeks?

- A. 2
- B. 4
- C. 8
- D. 12

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Q3

On advanced neuroimaging, neurometabolic alterations are similar in patients with concussion and those with which diagnosis?

- A. Clinical depression
- B. Schizophrenia
- C. Attention deficit disorder
- D. Obsessive compulsive disorder

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Q4

In the acute phase after concussion, which is the most important principle(s)?

- A. Protect the patient from further injury
- B. Quickly evaluate the patient and rule out more serious injury
- C. Return an athlete to play
- D. Both A and B

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Q5

Among the many symptoms a patient experiences post-concussion, which is the most common and long-lasting?

- A. Dizziness
- B. Balance dysfunction
- C. Irritability
- D. Headache

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Q6

Which tool was created specifically to standardize screening for vestibular and oculomotor problems related to concussion?

- A. Dix Hallpike
- B. Vestibular/Ocular Motor Screening (VOMS)
- C. Resting heart rate elevation test
- D. Neck Disability Index (NDI)

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Q7

Exercise tolerance testing can be used to assess dysfunction of which system in patients with post-concussion syndrome?

- A. Proprioception
- B. Autonomic nervous system
- C. Oculomotor control
- D. Musculoskeletal system

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Q8

Which of the following is an encouraging sign of recovery in patients with post-concussion syndrome?

- A. Increased time to fatigue
- B. Increased duration of naps
- C. Increased frequency of naps
- D. None of the above

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Q9

What is the latest timeline after suffering a concussion that vestibular and vision rehabilitation can be initiated and still offer benefit?

- A. 4 weeks
- B. 6 weeks
- C. 6 months
- D. It's never too late to initiate rehabilitation

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Q10

Which of the following diagnoses is likely in a patient <50 y/o with a history of concussion, cognitive decline, behavioral change, and damage on neuroimaging?

- A. Parkinson's disease
- B. Alzheimer's disease
- C. Chronic traumatic encephalopathy
- D. Multiple sclerosis

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Resources

<https://www.hugobonmedicine.org/health-conditions-and-diseases/concussion-of-the-brain/> - source: The OpenStax book is available for free at <https://cnx.org/content/col12076/1.26/concussion>.

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